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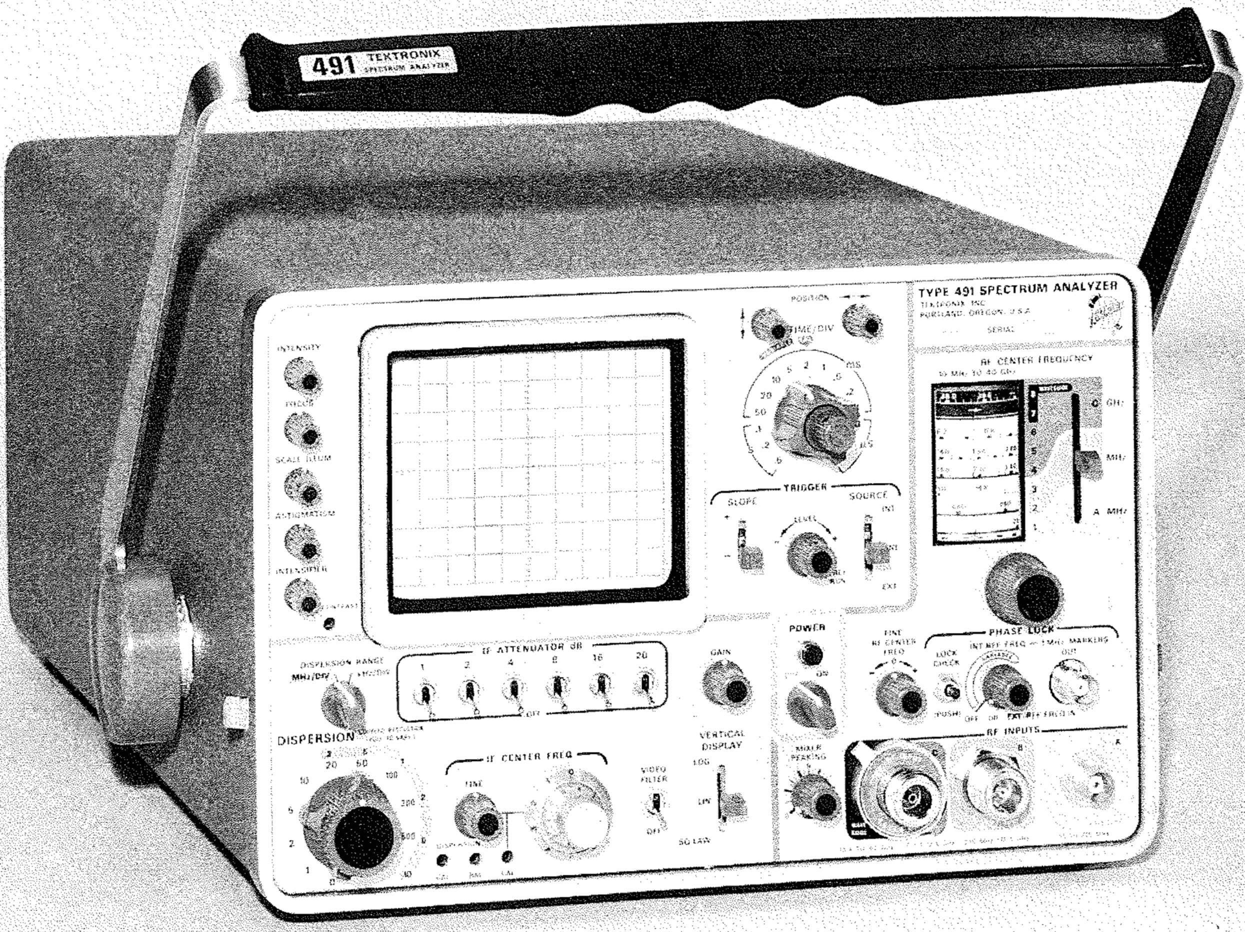

INTERPRETING SPECTRUM ANALYZER DISPLAYS

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Here is a portfolio of typical displays illustrating the versatility of spectrum analyzers in microwave measurement. By their clarity, these photos also provide a standard for proper instrument and equipment settings.

INTRODUCTION

Spectrum Analyzer displays illustrated in this article include: frequency stability (long- and short-term), amplitude modulation, frequency modulation, pulse modulation, ECM measurements, time-domain measurements, balanced modulator adjustment, antenna pattern measurements, video pulse spectra, and wide-dispersion measurements.

It is assumed that the reader is reasonably familiar with the operating principles of the superheterodyne spectrum analyzer. Therefore, the accompanying discussion stresses the interpretation of the displays rather than the procedures to generate them. For background reading, however, the appended bibliography is suggested.

All displays are actual, unretouched photos. Figures 1 through 33 were taken by Russ Myer of Tektronix using the following Tektronix instruments: spectrum analyzer plug-ins—1L10, 1L20, 1L30, 3L10; oscilloscopes—547, 549, 555, 564; time domain plug-ins—1S1, 3B4; signal sources—114, 184, 190. Figures 34 and 35 were taken by George Thiess of Microwave Physics Corp.

In all photos each horizontal division is one cm.

FREQUENCY STABILITY

The spectrum analyzer can measure both long- and short-term frequency stability. But the measurement is limited by:

(1) Spectrum Analyzer Stability. Obviously oscillator stability cannot be measured if the unit under test is more stable than the oscillators used in the spectrum analyzer.

(2) Resolution Capability. The analyzer's ability to determine the type and/or source of the instability depends strongly on the instrument's resolution bandwidth. For example, we cannot determine whether an oscillator is FM'ing at a 60 or 120 hertz rate when spectrum analyzer resolution is 500 hertz.

Short-term stability. This measurement concerns fast frequency changes such as those caused by power-supply noise and ripple, vibration or other random factors.

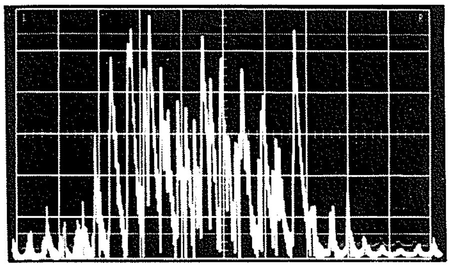

Figure 1.

Fig. 1 shows the random FM characteristic of a 3-GHz klystron. Spectrum analyzer dispersion is 2 kHz/cm and the resolution is 1 kHz. Oscillator FM is about 10 kHz —equivalent to 3 ppm.

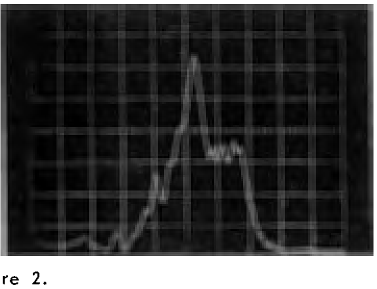

Figure 2.

A short-term stability measurement taken on a storage scope is shown in Fig. 2. A stored display is convenient here because of the extremely slow sweep speeds necessary to narrow-dispersion displays. Dispersion is 50 Hz/cm, resolution is 10 hertz and the input signal is 60 MHz. The test signal has a spectral width of about 150 hertz. This is equivalent to a stability of 2.5 ppm.

Long-term stability. Here we show the measurement of frequency drift as a function of time. The procedure depends on the characteristics of the spectrum analyzer used. One could photograph the screen at given intervals, and compare the position of the signal on the various photographs. If the spectrum analyzer has an auxiliary vertical output capable of driving a paper chart recorder, a permanent record can be obtained without photography.

The use of a storage oscilloscope is even more convenient with the scope set on a single sweep and triggered at appropriate intervals, thus storing a complete record of drift on the CRT.

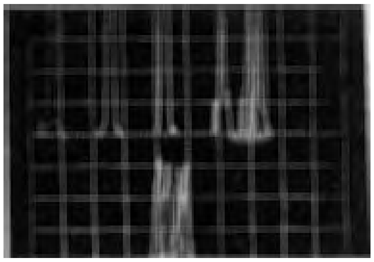

Figure 3.

For the storage-scope photo of Fig. 3, spectrum-analyzer dispersion is 1 kHz/cm, and the input frequency is 60 MHz. The upper half of the screen shows the drift of an unstabilized oscillator as it was heated. The oscilloscope was manually triggered at one-minute intervals. The drift was about 2 kHz per minute during the first three minutes, but diminished in rate thereafter, becoming nearly stable by the sixth minute. The total drift is on the order of 6.5 kHz or 108 ppm.

Temperature compensation can be computed easily since the amount and direction of drift is known. The lower half of the photo shows the drift after modifying the oscillator. Total drift is now about 1 kHz, an improvement of 6.5:1.

AMPLITUDE MODULATION

Modulation frequency and modulation percentage are the quantities usually desired in an AM measurement. Spectrum analysis is particularly useful in complex situations such as multi-tone modulation or overmodulation.

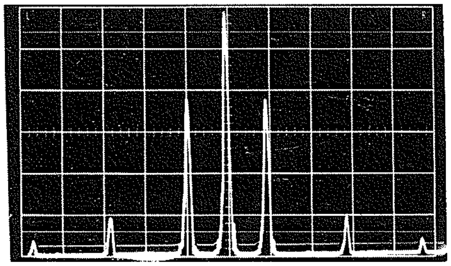

Figure 4.

Fig. 4 shows an overmodulated AM signal. Note the characteristic AM spectrum, consisting of a carrier and two sidebands, and the presence of additional, unwanted sidebands. Spurious sidebands, together with primary sidebands where amplitude is greater than one-half the carrier (100% modulation yields sidebands which are one-half the carrier amplitude) positively identify overmodulation.

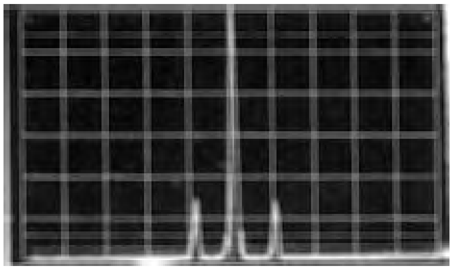

Figure 5.

Fig. 5 shows the same signal, but with the modulation reduced to 50%. The dispersion of the spectrum analyzer is 1 kHz/cm; the vertical display is linear. Thus, the modulating frequency is seen to be 1 kHz. Since the sideband amplitude is one-quarter that of the carrier, the modulation is 50%.

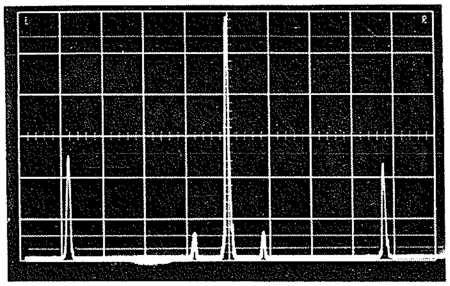
Figure 6.

Fig. 6 was photographed at a dispersion of 2 kHz/cm; vertical display is linear and center frequency is 60 MHz. Observe that the 60-MHz carrier is modulated at two frequencies; 1.6 and 7.5 kHz. Modulation is approximately 85% at 7.5 kHz and 20% at 1.6 kHz.

Overmodulation can be distinguished from two-tone modulation in two ways, evident by comparison of Figs. 4 and 6: (1) Spacing between overmodulated sidebands is equal while two-tone sidebands are arbitrarily spaced; (2) The amplitude of overmodulated sidebands decreases progressively from the carrier, but amplitude of two-tone sidebands is determined by the modulation percentage and can be arbitrary.

FREQUENCY MODULATION

FM measurements generally concern modulation frequency, spectral width, index of modulation and deviation. A typical FM spectrum is shown in Fig. 7. Dispersion is 200 kHz/cm and the spectral width is about 1 MHz. The exterior modulation envelope, typically resembling a $\cos^2$ curve, identifies the frequency modulation. The interior envelope appears on the screen because the FM rate is of the same order as the analyzer's resolution bandwidth. Consequently side bands are not resolved adequately and the trace cannot return to the base line at every pulse.

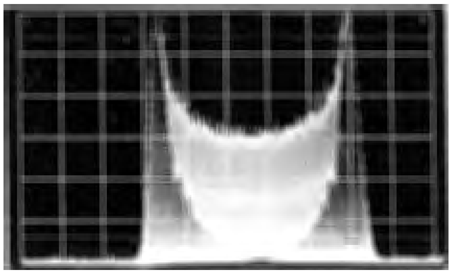
Figure 7.

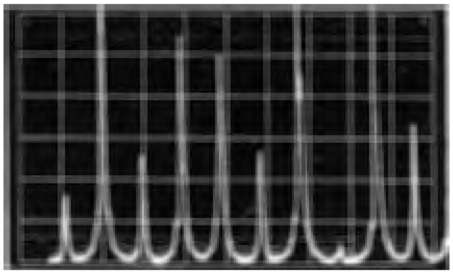
Figure 8.

The same FM signal appears in Fig. 8 but the dispersion has been reduced to 10 kHz/cm and the resolution is 1 kHz. The double-envelope display does not occur and the sidebands are clearly visible. Modulation frequency is 10 kHz.

FREQUENCY DEVIATION

There is no clear relationship between spectral width and deviation, since, in theory, the FM spectrum extends to infinity. But in practice, the spectral level falls quite rapidly as shown in Fig. 7. Experience indicates that the deviation is on the order of ½ the observed spectral width.

Very accurate deviation measurements can be obtained if the modulation frequency can be varied. It can be shown that for FM the carrier goes to zero at a modulation index (ratio of deviation to modulating frequency) of 2.4; other nulls occur at other modulation indices—e.g., the second null occurs at an index of 4.8.

This knowledge is the basis of a very powerful deviation measurement method known as the carrier null method. Figs. 9, 10 and 11 demonstrate this method. These figures were taken at a dispersion setting of 200 kHz/cm and a resolution of 100 kHz.

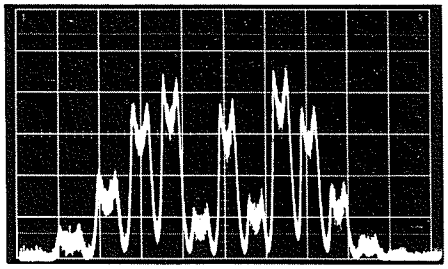
Figure 9.

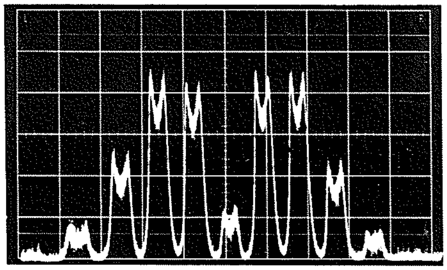
Figure 10.

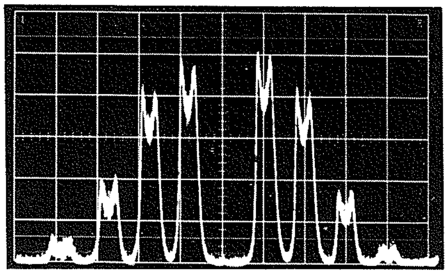
Figure 11.

Note that the spectral width is the same as in Fig. 7 but the modulating frequency has been increased so that individual sidebands can be resolved. In all three figures, the signal has been adjusted so that the carrier is at the center of the screen.

Fig. 9 shows a fairly large carrier. In Fig. 10, the modulation frequency is increased and the carrier level has decreased. In Fig. 11, the modulation frequency is increased further so that a null occurs at the position of the carrier. Since the observed modulating frequency is 200 kHz and since the observed index of modulation is 2.4, the deviation is 480 kHz.

PULSE MODULATION

Square pulses—A pulse-modulated signal generates a complex spectrum of the familiar sin x/x type. For example, a square pulse generates a spectrum described by $\sin \pi ft/\pi ft$, where t is pulse width and f is frequency deviation from the carrier. Fig. 12 shows the spectrum of a 1-GHz carrier modulated by a 0.67-μs square pulse. Observe that the spectrum is entirely above the baseline, whereas Fourier theory indicates that adjacent lobes should be out of phase by 180 deg. This phenomenon occurs because the spectrum analyzer is insensitive to phase. A second apparent inconsistency is that while the spectrum should be (in theory) solid, the display consists of vertical lines. This stems from the fact that the superheterodyne spectrum analyzer is not a real-time device. It takes many pulses to trace out the spectrum. Thus, each vertical line represents the sampling of one pulse.

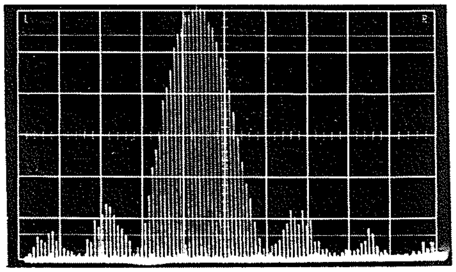
Figure 12.

Now we can manipulate the spectrum-analyzer controls to determine the characteristics of the signal. In Fig. 12 the spectrum-analyzer dispersion is 1 MHz/cm and the vertical display is linear. For a square pulse the theoretical pulse width $t = 1/f_o$, where f_o is the spectral sidelobe width. From Fig. 12, $f_o \simeq 1.5$ MHz. Therefore $t = 0.667\ \mu$s. Assuming that the vertical display is perfectly linear, we find that the ratio of main lobe to first sidelobe is 6:1.2. This is equivalent to 14 dB. More accurate measurement using the spectrum analyzer's calibrated attenuators gives a ratio of 13 dB. Theoretically, the main lobe is 13.2 dB greater than the first sidelobe.

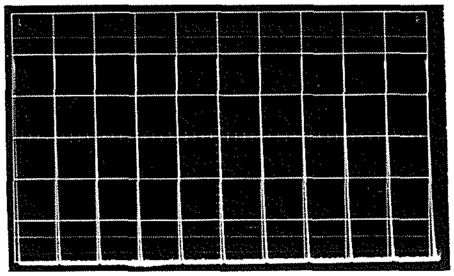

Figure 13.

Fig. 13 shows the same signal but with the dispersion set to zero. (This means that the sweep is only in time rather than in frequency; the analyzer is now a microwave receiver with a CRT readout). The display is merely a set of equally spaced lines. Since each line represents a pulse, the pulse rate can be easily measured. Here the scope is sweeping at a 1-ms/cm rate; one cycle of the modulating pulse requires 1 ms. The pulse rate is therefore 1 kHz.

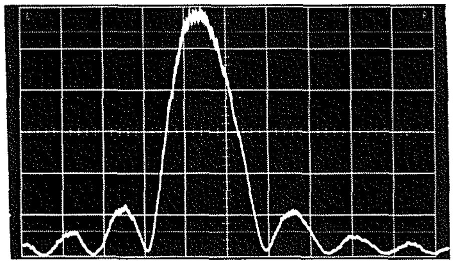

Figure 14.

As previously indicated, it is not the lines themselves, but only their envelope that is of interest. Sometimes it is advantageous to present an integrated display showing only the outline of the spectrum. Such a display, shown in Fig. 14, is obtained by using a postdetection (video) filter. This kind of display has several advantages: The baseline and its accompanying glare are eliminated and weak signals are more apparent. Noise is reduced automatically by integration and anomalies are removed. On the other hand, bandwidth and sensitivity are reduced (often by 1 to 5 dB). Sweep speed also decreases.

Sometimes it is desirable to limit the signal's spectral width by filtering, pulse shaping, etc. It then becomes important to identify low-level signals. This is accomplished by operating the analyzer in its logarithmic mode so that low level signals are enhanced relative to large signals.

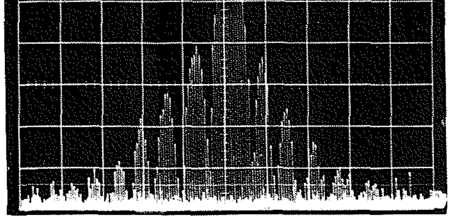

Figure 15.

In the logarithmic display of Fig. 15, the main lobe and the first eight side lobes are discernible.

PULSES IN THE PRESENCE OF FM

All signal sources, regardless of how carefully designed, have a certain amount of incidental FM. This limits the type of pulse modulation that can be used.

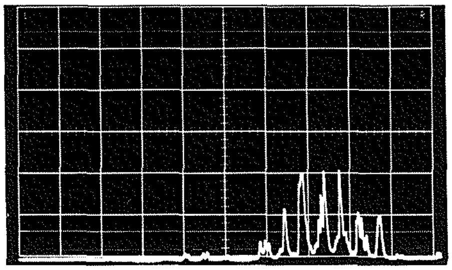

Figure 16.

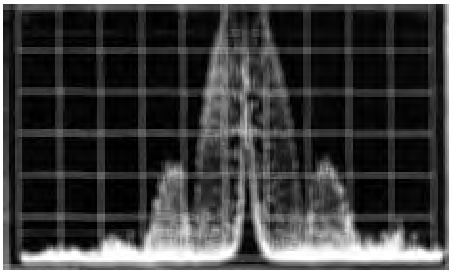

Figure 17.

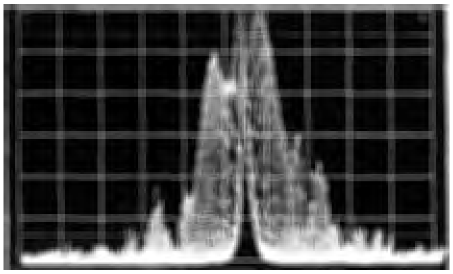

Figure 18.

Fig. 16 shows a carrier with incidental FM deliberately applied. Analyzer dispersion is 5 kHz/cm and FM spectral width is on the order of 12 kHz. Fig. 17 shows the carrier with the FM removed. (The large signal in the center of the main lobe is due to a poor on-off ratio in the modulator. This phenomenon is discussed in another section.) Fig. 18 shows the combination of FM and pulse modulations. Note that the signal is not symmetrical and that the sidelobes are uneven. An extensive discussion of pulsed RF in the presence of FM is found in Montgomery.[1]

EFFECTS OF PULSE SHAPING

Spectral width can be controlled by several means, including that of pulse shaping. The effect of pulse shape on spectral distribution s illustrated in the following spectrum analyzer displays. Fig. 19 shows the conventional sin x/x spectrum of an RF signal modulated by the square pulse of Fig. 20.

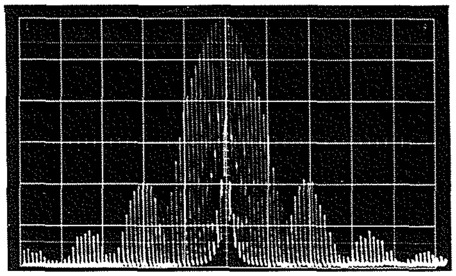

Figure 19.

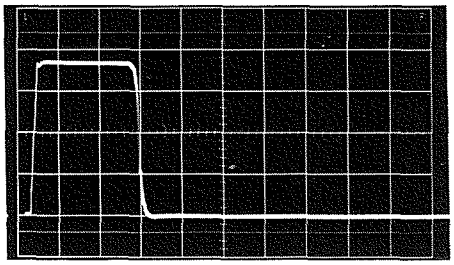

Figure 20.

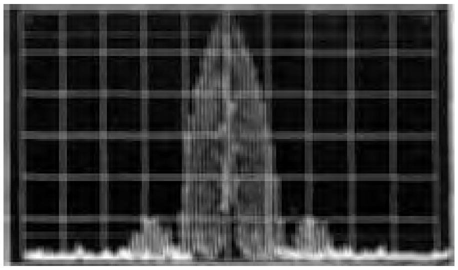

Figure 21.

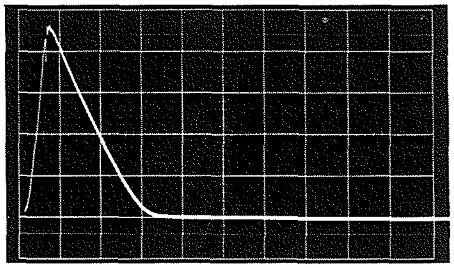

Figure 22.

Fig. 21 shows an RF signal modulated by the asymmetrical triangular pulse in Fig. 22. Note that the sidelobes in Fig. 21 are considerably lower than those in Fig. 19.

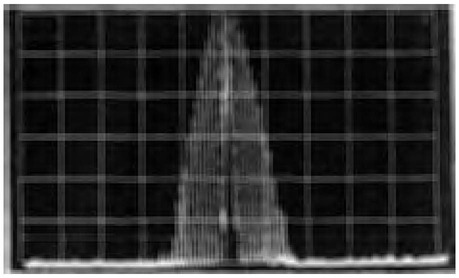

Figure 23.

Fig. 23 shows an RF signal modulated by the symmetrical triangular pulse shown

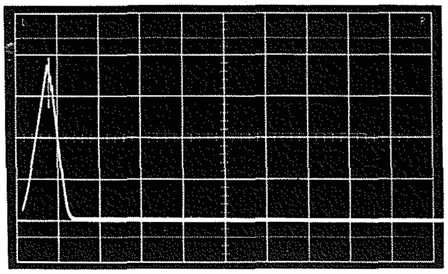

Figure 24.

in Fig. 24. Note that this spectrum is almost completely devoid of sidebands. As the effective pulse width changes, so does the width of the main lobe. The spectrum analyzer dispersion was adjusted between Figs. 19, 21 and 23, so that the main lobe would continue to occupy approximately the same number of divisions—this to better illustrate the disappearance of the sidelobes.

ECM MEASUREMENTS

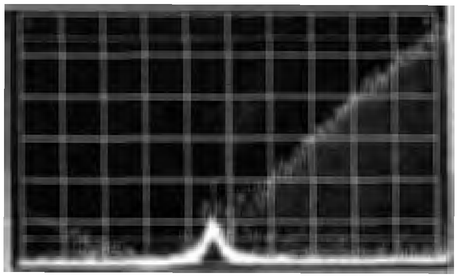

Figure 25.

In countermeasure work, intelligence is sometimes transmitted so as to be masked by another signal. An example is the transmission of information at the null point of a pulsed RF signal. Fig. 25 shows transmission of a 100-kHz-wide signal at the null point. The pulsed RF signal has been expanded using the scope horizontal magnifier control. The cw signal at the null point is clearly discernible on the analyzer but less so to a ferret receiver.

PULSE MODULATOR ON-OFF RATIO

Sometimes the carrier to be pulsed is not turned off completely during the pulse-off time. This results in a combination of cw and pulsed signals. Measurement of on-off ratio is complicated by the fact that the spectrum analyzer has higher sensitivity for cw signals than for pulsed signals. The ratio in sensitivity is $3/2\ t\beta$, where t is pulse width and β is spectrum analyzer's 3-dB bandwidth (resolution bandwidth).

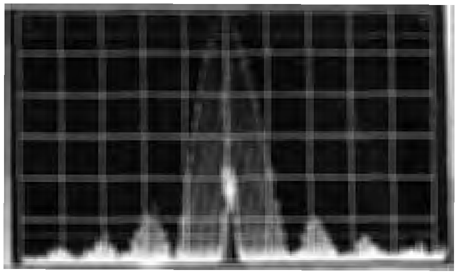

Figure 26.

Fig. 26 shows a typical pulsed RF signal generated by a modulator that has a poor on-off ratio as indicated by the large signal within the main lobe. Dispersion is 0.5 MHz/cm (pulse width 1.3 μs), resolution bandwidth is 100 Kc and the vertical display is linear. To find the on-off ratio we compute the loss in pulse sensitivity relative to cw:

$$3/2\ (1.3)\ (10^{-6})\ (10^{5}) = 1.95 \times 10^{-1}$$

$$\ldots\ldots\ 20 \log_{10} 1/0.195 = 14.2\,\text{dB}$$

Next, from the vertical deflection in Fig. 26, the cw signal amplitude is 1/3 that of the pulsed signal. This is equivalent to a difference of 20 $\log_{10} 3 = 9.5$ dB. The total on-off ratio is $9.5 + 14.2 = 23.7$ dB.

DUAL-BEAM SPECTRUM ANALYSIS

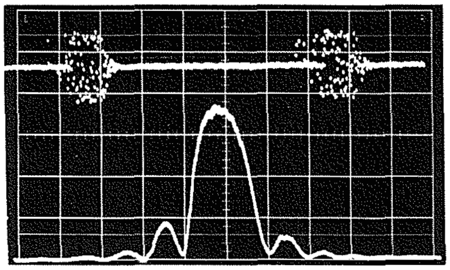

Figure 27.

It is sometimes useful to simultaneously observe both the RF spectrum and modulating waveform, as when shaping a pulse to generate a desired spectrum. With a dual-beam arrangement, we simultaneously observe changes in the modulating pulse and the resultant frequency spectrum. With microwave sampling scopes we can observe both the modulated carrier and the modulating pulse in time domain. Fig. 27 shows a dual-trace display of a 1-GHz carrier modulated by a 1-μs pulse. The upper trace is in time domain at 1 μs/cm. The lower trace is in frequency domain at 1 MHz/cm.

TIME-DOMAIN MEASUREMENTS

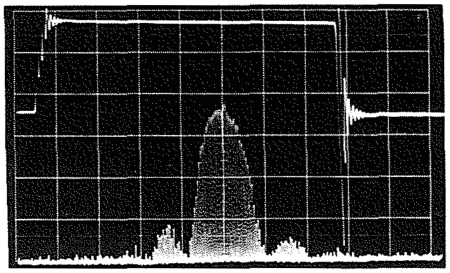

Figure 28.

Some spectrum analyzers can function both in time and frequency domains. Such instruments are not meant to replace oscilloscopes, as their sensitivity is rather poor (100 mV/cm) and their input impedance is low (50 Ω). In microwave systems, however, where detectors like to be terminated in 50 Ω, useful information can be obtained with such analyzers. Fig. 28 is a double-exposure photo showing the time domain characteristics of the modulating pulse as the upper trace and the output spectrum as the lower trace. The same display could have been obtained with a dual-beam oscilloscope.

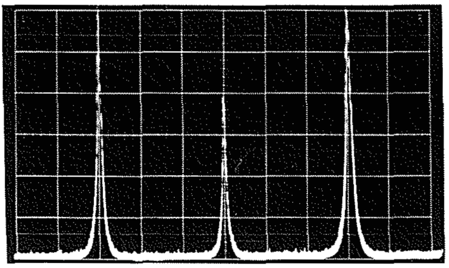

Figure 29.

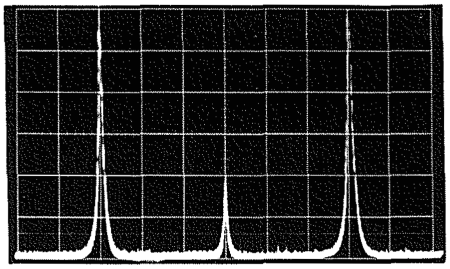

Figure 30.

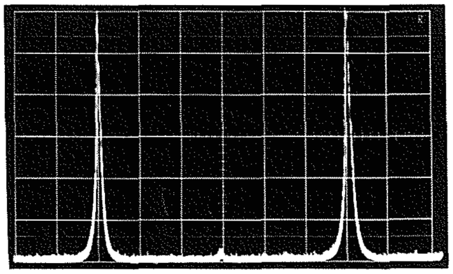

Figure 31.

BALANCED-MODULATOR ADJUSTMENT

Balanced modulators often are used to impose suppressed-carrier modulation. Figs. 29 to 31 illustrate how this application can be monitored by a spectrum analyzer. Fig. 29 shows a modulator that is not well balanced. The carrier is almost as large as the side bands. The balance controls are now adjusted to an intermediate stage of performance as shown in Fig. 30. The fully adjusted system, with the carrier almost entirely suppressed, yields the spectrum of Fig. 31.

ANTENNA-PATTERN MEASUREMENTS

The spectrum analyzer also can be used to provide antenna-pattern data. Assume that the transmitting antenna under test is stationary. A transmitted pulse is picked up by a receiving antenna and displayed on the analyzer as a typical sin x/x spectrum. If the analyzer's input frequency is centered on the main lobe and the dispersion reduced to zero we get a set of equal amplitude lines across the screen. Each line represents one transmitted pulse.

Assume now that the test antenna is rotating. A very strong signal is received when the pickup antenna is located in the main lobe of the transmitting-antenna pattern; signals are weaker in the sidelobes and minimal in the pattern nulls. If the spectrum analyzer is swept very slowly, so slowly in fact that one sweep corresponds to 360 deg. of antenna rotation, the CRT screen can be calibrated in degrees to display a complete antenna pattern.

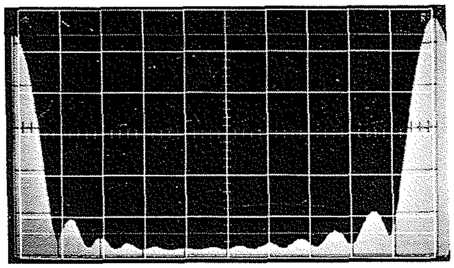
Figure 32.

Fig. 32 shows such a simulated antenna pattern. The ten horizontal screen divisions correspond to 360 deg. of antenna rotation, 36 deg. per division. Since the vertical display is linear with voltage we can compute amplitude differences directly. Thus, 3 dB is 0.707 of maximum deflection or 0.707 x 5.8 = 4.1 divisions.

The main lobe of the pattern is about one horizontal division wide at the 4.1 division height and the antenna therefore has a beam width of about 36 deg. The center of the screen corresponds to the 180-deg. position. The ratio of main lobe deflection (5.8 divisions) to that at 180-deg. rotation (0.2 divisions) is the antenna's front-to-back ratio, which for this antenna is 11.6, or 21.3 dB.

One precaution: the receiving antenna must have very low sidelobes and a narrow beam width in comparison to the transmitting antenna so as not to affect the recorded pattern. Keep in mind also that the analyzer must be swept quite slowly to record the pattern. A paper chart recorder or storage scope can therefore, be very helpful. Fig. 32 was displayed on a storage scope.

VIDEO PULSE SPECTRA

It is sometimes useful to examine the Fourier spectrum of a video-pulse train directly, without modulating a carrier. Whereas in a pulsed RF signal the spectrum is centered around the carrier frequency, the spectrum for a video pulse goes to zero frequency.

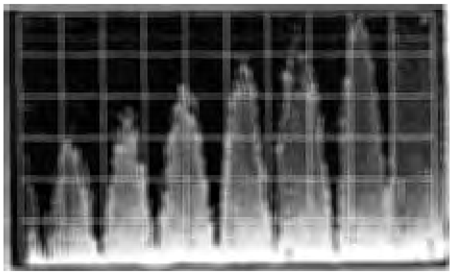
Figure 33.

Most spectrum analyzers having wide dispersions cannot display such low frequencies. However, some spectrum analyzers using balanced mixers for local oscillator suppression are suitable. Fig. 33 shows the spectrum of a 0.4-μs pulse. Analyzer dispersion is 2 MHz/cm.

WIDE DISPERSION MEASUREMENTS

A new class of spectrum analyzers having gigahertz dispersions recently has appeared on the market. The accompanying figures illustrate two applications of these new devices. Fig. 34 shows eleven signals spaced at 1-GHz intervals from 2 to 12 GHz. Analyzer dispersion is 10 GHz.

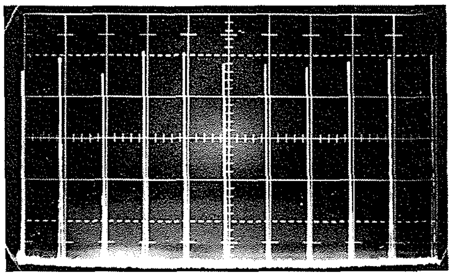
Figure 34.

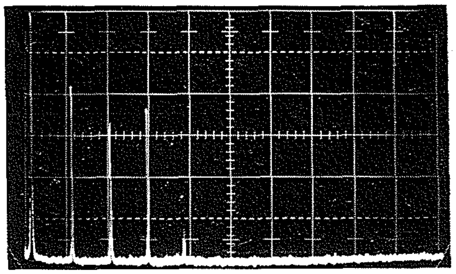
Figure 35.

Fig. 35 shows the harmonics of a 900-Mc MHz transistor oscillator. The spectrum analyzer is sweeping from 1.7 to 12.5 GHz. We observe that this oscillator has substantially no output beyond the 6th harmonic.

BIBLIOGRAPHY

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Feigenbaum, M. H. "Introduction to Spectrum Analyzers." MicroWaves. April 1963.

Frisch, A., Engelson, M. "How to Get More Out of Your Spectrum Analyzer." MicroWaves. May 1963.

Myer, R. "Getting Acquainted with Spectrum Analyzers." Tektronix publication #A-2273.

REFERENCE

[1] Montgomery, Techniques of Microwave Measurements (New York: McGraw-Hill, 1945), RADLAB Series, Vol. XI.

SERVICE NOTES

TEKTRONIX PROBES — PROBE-IDENTIFICATION TAGS

While engaged in multi-probe applications, have you ever experienced frustration in quickly locating correlating probe ends or determining which probe cable led to which probe?

We have available, plastic probe-identification tags (see Figure 1) that help you locate correlating probe ends quickly and/or determine which probe cable leads to which probe.

These tags come in two versions, one version has a .125-inch center hole to fit around the smaller cable used on some of our probes, the other has a .178-inch — .185-inch center hole to fit around the larger cable used on other of our probes. The tags are packaged 20 tags of a center-hole size to a package — 2 tags each of ten colors.

For use on probes with the smaller cable order Tektronix part number 334-0789-00. For use on probes with the larger cables, order Tektronix part number 334-0789-01. Please order through your local Tektronix Field Engineer, Field Representative, or Distributor.

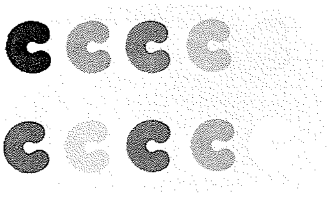
Figure 1. Probe Identification Tags

TYPE 310 AND TYPE 310A—CALIBRATION-PROCEDURE NOTES

In the Type 310 and Type 310A Instruction Manual, on page 5-12 of the Calibration Procedure section, paragraph "d" reads: "d. Connect the CAL OUT connector to the TRIG INPUT connector as well as to the INPUT connector." Change this to read: "d. Connect 0.2 V from the CAL OUT connector to the TRIG INPUT connector as well as to the vertical INPUT connector."

The specifications for the Type 310 and 310A call out 0.2 V as the trigger requirements for external trigger on these instruments. Failure to repeat the information in the calibration section of the instruction manual has caused confusion for some when calibrating these instruments. Our apologies to these people. We hope this information clears the confusion.

NEW FIELD MODIFICATION KITS

BLANK PLUG-IN

This field modification kit supplies the necessary hardware to construct a skeleton plug-in unit for use in a Tektronix Type 560 Series Oscilloscope. This kit is intended for those who wish to design their own special-purpose plug-in units.

From the information supplied in the kit, a skeleton plug-in unit can be constructed so as to be compatible with a specific Type 560 Series Oscilloscope or with several (or all) of these instruments.

The kit also supplies pertinent information so that the special plug-in may be designed to operate in conjunction with either a Tektronix-produced plug-in unit in a Type 560 Series Oscilloscope or with a second special plug-in unit.

This modification kit is applicable to the following Type 560 Series Oscilloscopes: 560, 561, RM561, 561A, RM561A (including MOD 210C), 564, RM564, 565, RM565, 567, and RM567.

Order through your local Tektronix Field Office, Field Engineer, Field Representative, or Distributor. Specify Tektronix part number 040-0245-00.

TYPE 502 DUAL-BEAM OSCILLOSCOPE—VARIABLE TIME/CM

This modification adds a VARIABLE control to the TIME/CM switch on the Type 502 Oscilloscope. This provides a sweep rate continuously variable uncalibrated from 1 μsec/cm to over 12 s/cm.

Order through your local Tektronix Field Office, Field Engineer, Field Representative, or Distributor. Specify Tektronix part number 040-0221-00.

TYPE 524K TELEVISION OSCILLOSCOPE — PROBE POWER

This modification installs a probe power socket on the front panel of the Type 524D Television Oscilloscope. This allows a P500CF cathode-follower probe to be used with the oscilloscope. DC filament voltage for the probe's vacuum tube reduces hum to a minimum.

The P500CF Probe presents a low input capacitance with minimum attenuation.

This modification kit replaces the Type 524D Probe Power Modification Kit (Tektronix part number 040-0059-00) which provided AC filament voltage for the probe's vacuum tube. It will also convert a Type 524D with the 040-0059-00 modification kit installed from AC to DC filament voltage for the probe's vacuum tube.

Order through your local Tektronix Field Office Field Engineer Field Representative or Distributor. Specify Tektronix part number 040-0273-00.

CORRECTION NOTE

In the October, 1966 issue of Service Scope there is a typographical error on page 4. The set of equations just opposite Figure 4, as printed reads:

$$V_{oc_t} = \frac{V_{oc_1} \times 417\ k}{Z_{th_1} + 4.7\ k}$$

It should read:

$$V_{oc_t} = \frac{V_{oc_1} \times 4.7\ k}{Z_{th_1} + 4.7\ k}$$

USED INSTRUMENTS FOR SALE

1—Type 511 Oscilloscope, sn 111. Price: $175. Contact: R. R. Chittenden, Electro Mechanical Company, P.O. Box 7886, Portland, Oregon. Phone: 289-8885.

1—Type 517 Oscilloscope, sn 781, with power supply and probe, good condition. Would like cash or a Type 541 Oscilloscope with a Type 53/54 C Dual-Trace Plug-In Unit. Contact: G. L. Boelke, 505 Main Street, West Seneca, New York 14224.

1—Type 515A Oscilloscope, sn 1687. Contact: Mr. George Dupont, New York Stock Exchange. Phone: 212-HA 2-4200 x 463.

1—Type Q Transducer and Strain Gage Plug-In Unit, sn 1742. About 2 years old, new condition. Price: $275.00, FOB West Palm Beach, Florida. Contact: Jerry Strasser, Solitron Devices, Inc., 1177 Blue Heron Blvd, Riviera Beach, Florida. Phone: 305-848-4311.

1—Type 585A Oscilloscope; 1—Type 82 Dual-Trace Plug-In Unit; 1—Type 202-2 Scope-mobile® Cart; and 1—C12R Oscilloscope Camera with projected graticule. Available for immediate delivery. Price: 10% off catalog list price. Contact: Mr. H. Brawley, 25 Hemlock Street, Norwood, Massachusetts. Phone: 617-769-3888.

1—Type 511 Oscilloscope, sn 438, P11A CRT. Price: $150.00. Contact: R. S. Komp, Box 372, Fairhaven, New York 13064. Phone: 315-947-1921.

1—Type 131 Amplifier. Approximate age 14 months. Contact: Tom Thompson, Bemis Bag Company, 325 - 27th Avenue, N.E., Minneapolis, Minnesota.

1—Type 105 Square Wave Generator. Price: $175. 1—Type 112 Preamplifier; 1—Type 121 Preamplifier. Price: $110 each. 1—Type 180S1 Time Marker. Price $290. We are interested in either purchasing or trading for used Type 321 Oscilloscope and Type 575 Curve Tracer. Contact: Denes Roveti, Technical Director, Roveti Instruments, 1643 Forest Drive, Annapolis, Md. 21403.

1—Type 561A Oscilloscope, sn 6000; 1—Type 3S76 Dual-Trace Sampling Plug-In Unit, sn 402; 1—Type 3T77 Sampling Sweep Plug-In Unit, sn 340. Contact: Allen Avionics, P. O. Box 350, Mineola, New York.

1—Type 512 Oscilloscope, sn 1997, includes most modifications. Was completely overhauled in 1961. Contact: Mr. J. R. Harkness, Briggs & Stratton Corp., P.O. Box 702, Milwaukee, Wis. 53201. Phone: 414-461-6600.

1—Type 551 Oscilloscope, sn 757; 1—Type 53/54 C Dual-Trace DC Plug-In Unit, sn 20847; 1—Type 53/54 H Wide-Band High-Gain DC Plug-In Unit, sn 591. Excellent condition, less than 200 hours total operation. Price: $1400 total, or will sell separately. Contact: Dr. B. J. Wilder, Neurology, J. Hillis Miller Health Center, University of Florida, Gainesville, Florida. Phone: 904-376-3211, Ext. 5418.

1—Type 544 Oscilloscope; 1—Type 1A2 Dual-Trace Plug-In Unit; 1—P6016 AC Current Probe;

1—Type P Fast-Rise Test Plug-In Unit, sn 2530. About 4 years old, new condition. Price: $50.00.

USED INSTRUMENTS WANTED

1—Type 531, 532 or 533 Oscilloscope less plug-in. Please state condition and price when answering. Contact: Mr. J. R. Harkness, Briggs & Stratton Corp., P.O. Box 702, Milwaukee, Wisconsin 53201. Phone: 414-461-6600.

1—Type 515 or Type 535 Oscilloscope. Contact: Fidelitone, Nick L. Miku, 6415 North Ravenswood Avenue, Chicago, Illinois 60626. Phone: 312-274-0075.

Wanted to buy used Type 516 Oscilloscope. Contact: Tim Denning, Tim's Electronic Service, Houghton, Iowa. Phone: 319-469-2364.

Used 500 Series Oscilloscope, at least 15 MHz band. Contact: Jim Worthington, 301 Longview Drive, Monroeville, Pennsylvania.

1—Type 310 or Type 310A Oscilloscope. Contact: Mr. R. L. Goodman, Clark Dunbar, 325 Jackson St., Alexandria, Louisiana. Phone: 318-443-7306.

1—used Type 515 Oscilloscope. Contact: Mr. John Bohinko, 117 Abbot Street, Plains, Pennsylvania.

1—Type 543B Oscilloscope; 1—Type 1A2 Dual-Trace Plug-In Unit; 1—Type 1A7 Differential Amplifier Unit. Contact: Brooks Delecktro, 41 East 42nd Street, New York, New York 10017. Attn: Miss Brooks. Phone: 212-687-4940.

Used Type 536 Oscilloscopes and Type T Time-Base Generator Plug-In Units. Contact: Mr. Julie, Julie Research Laboratories, 211 West 61st Street, New York, New York. Phone: 212-Circle 5-2727.

For complete information contact your Field Engineer, Field Representative, or Distributor.

MISSING INSTRUMENTS

Following are the instruments reported to us in the past 60 days as lost or presumed stolen. With each instrument (or group of instruments), we list their legal owner. Should you have any information on the present whereabouts of these instruments, or information that might lead to their eventual recovery, please contact the individual or firm listed here as the owner. If you prefer, you may relay your information to any local Tektronix Field Office, Field Engineer, or Field Representative.

1—Type 533A Oscilloscope, sn 3465; 1—Type CA Plug-In Unit, sn 19411; 1—Type D Plug-In Unit, sn 8630; 1—Type Z Plug-In Unit, sn 541, were removed from the premises of Electramatic, Inc., over Labor Day weekend. Anyone having information concerning these instruments, contact Mr. Arnold Gilbertson, 3324 Hiawatha Avenue, Minneapolis, Minnesota 55406. Phone: PA 1-5074.

Mr. Forrest Barker with the Los Angeles City College, has lost his four 502 Oscilloscopes. The serial numbers are 8506, 8854, 9280 and 9779. Mr. Barker would appreciate hearing from anyone with information on the whereabouts of his instruments. His phone number is 213-633-9141, ext. 259.

1—Type 310A Oscilloscope, sn 21352. This instrument disappeared, and is presumed stolen, from a car about two months ago. If you have information concerning this instrument, please contact Mr. Bill Wise, Mosler Safe Company, Pittsburgh, Pennsylvania.

1—Type 516 Oscilloscope, sn 1539, was reported missing last week of September, 1966. Contact: M. J. Coppler, Florida Telephone Corp., Leesburg, Florida. Phone: 904-787-4525.

1—Type 422 Oscilloscope, sn 1672 disappeared and is presumed stolen from Jean C. Bisset, "GEWSEN" Western GEEIA Region, McClellan AFB, California 95628.

1—Type 321 Oscilloscope, sn 000106 presumed stolen. Anyone having information concerning this instrument please contact: Mr. Vourganas, Baird Electronics, 630 Dundee Road, Northbrook, Illinois. Phone: 312-272-2300.

1—Type 321A Oscilloscope, sn 1366 disappeared on approximately May 13, 1966. Contact: Univac, Plant 3, St. Paul, Minnesota.

1—Type 321A Oscilloscope, sn 00194 reported missing on October 25, 1966. Contact: Univac Division (Sperry-Rand), 3645 Warrensville Center Road, Cleveland, Ohio 44122. Attn: W. Uminski. Call Collect, Phone: 216-752-7000, Ext. 36.

Service Scope

USEFUL INFORMATION FOR

USERS OF TEKTRONIX INSTRUMENTS

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon, U.S.A. 97005

FRANK L. GREENWOOD
DEPT. OF TRANSPORT
TELECOMMUNICATIONS & SYSTEM LAB.
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